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December 22, 1999

MEMORANDUM TO: Stuart A. Richards, Director
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

FROM: Jack Cushing, Project Manager, Section 2
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF MEETING WITH ABB-CE TO DISCUSS REACTOR COOLANT PUMP SEAL MODEL DEVELOPMENT

On December 13, 1999, the NRC staff met with representatives of ABB-CE to discuss the development of a reactor coolant pump (RCP) seal model. Attachment 1 is a list of the meeting participants. Attachment 2 is a copy of the meeting slides.

On November 9, 1999, the NRC staff issued the closeout letter for Generic Safety Issue 23, "Reactor Coolant Pump Seal Failure." In the closeout letter, the staff said they would work with the industry to develop additional RCP seal models, but until then it will continue to use the Rhodes seal model. On November 18, 1999, the CEOG Executive Committee and NRC management met. An action item from the November 18, 1999, meeting was to schedule a meeting to discuss the development of an RCP seal model for ABB-CE plants.

The purpose of the meeting was for ABB-CE to brief the staff on the development of their RCP seal model and for the staff to provide feedback. The CEOG is preparing a mechanistic and a risk informed seal failure model. The meeting commenced with Mr. David Finnicum, of ABB-CE presenting the objectives of the RCP seal failure model. The objectives are to revise the CEOG model for failure of RCP seals given a loss of cooling to the seals and to close out the RCP seal failure issue for ABB-CE plants. The model will be applicable to the seals in use at ABB-CE plants.

The main tasks involved in developing the seal model include a description of the seals, a discussion of seal failure mechanisms, a mechanistic seal failure model, quantifying model parameters, developing a leak rate model and submitting a topical report to the NRC. The description of the seal design and operation includes critical support system considerations. The technical description of the seal failure mechanisms will address binding, hydraulic instability and the contributing factors of whether the controlled bleed off is isolated or not isolated, or if the RCP is running or not running. RCP seal failure quantification will use operating experience data, seal test data, and expert judgement. The staff suggested that it is preferable to use data either from actual loss of coolant events or from RCP seal tests rather than expert judgement. The experts will be from the utility RCP system engineers, the seal manufacturer representatives and the ABB seal expert. The leak rate model will develop event tree end states for postulated combinations of seal stage failures. The topical report will be submitted to the NRC by July 2000.

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Mr. Finicum then briefed the staff on the RCP seal design general features. The seals are hydrodynamic seals consisting of four stages (Palo Verde has three stages), including the vapor stage. There is equal pressure reduction per stage and each stage is capable of full system pressure. Normal controlled bleed-off is 1-1.5 gpm and seal injection is not required. The instrumentation to monitor seal performance includes individual stage pressure, controlled bleed-off flow and controlled bleed-off temperature.

Mr. Finicum then discussed the RCP seal design testing that has been performed to date. There have been six RCP seal tests performed in the ten-year period from 1978-1988. The tests involved a variety of seal designs. There have been 20 events involving a loss of cooling to one or more RCPs at a CE plant. The total number of stages involved was 232, the total number of failed stages was four, and the total number of failed seals was zero.

In closing, the CEOG stated that they will not conduct any additional tests or develop a detailed thermal-hydraulic model of the seals. Their goal is to submit the topical report by July 2000 and that this model will close out the seal failure issue for ABB plants. The NRC staff recommended another meeting to discuss the details of the RCP seal model after the initial quantification of the model parameters has been completed.

Project No. 692

Attachments: 1. Meeting Participants
2. ABB/CEOG Slides

cc w/atts: See next page

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cc: Mr. Gordon C. Bischoff, Project Director
CE Owners Group
ABB Combustion Engineering Nuclear Power
M.S. 9615-1932
2000 Day Hill Road
Post Office Box 500
Windsor, CT 06095

Mr. Ralph Phelps, Chairman
CE Owners Group
Omaha Public Power District
P.O. Box 399
Ft. Calhoun, NE 68023-0399

Mr. Ian C. Rickard, Director
Nuclear Licensing
ABB Combustion Engineering Nuclear Power
2000 Day Hill Road
Post Office Box 500
Windsor, CT 06095

Mr. Charles B. Brinkman, Manager
Washington Operations
ABB Combustion Engineering Nuclear Power
12300 Twinbrook Parkway, Suite 330
Rockville, MD 20852

ATTENDANCE LIST

MEETING ON THE CE OWNERS GROUP PROPOSED RCP SEAL MODEL DEVELOPMENT

December 13, 1999

ABB-CE

A. Rudyk
D. Finnicum
V. Paggen
P. Hijeck

FLOWSERVE

D. Berg

NRC

J. Cushing
S. Dembek
J. Wermiel
J. Jackson
E. Rodrick
C. Jackson
N. Saltos
A. Buslik
M. Reinhart

Attachment 1

Project to Revise the ABB/CEOG RCP Seal Failure Model

Generic Issue 23, "RCP Seal Failure"

December 13, 1999

US Nuclear Regulatory Commission

Rockville, MD

PRESENTATION

- *Purpose of Meeting*
- *Objectives of Project to Revise RCP Seal Failure Model*
- *Summary of Proposed Tasks*
- *Project Schedule*
- *Summary of Some Relevant Design and Operating Experience Information*
- *Discussion*
- *Closing Remarks*

Attachment 2

PURPOSE

- *Summarize the Proposed Approach for Updating the ABB/CEOG Model for RCP Seal Failure Given Loss of Seal Cooling*
- *Get NRC Feedback on Proposed Approach*

RCP SEAL FAILURE MODEL OBJECTIVES

- **Revise CEOG Model For Failure of RCP Seals Given Loss of Cooling To Address NRC Concerns**
  - **Develop Technical Description of Seals**
  - **Develop Technical Discussion of Failure Mechanisms of Concern**
  - **Develop and Quantify Mechanistic Seal Failure Model**
  - **Incorporate Leak Rate Model**
- **Close Out RCP Seal Failure Issue For ABB Plants**

Revision of RCP Seal Failure Model - Main Tasks -

① **Develop Technical Description Of Seal Design and Operation**

- ➢ Includes Support System Considerations

② **Develop Technical Descriptions of Seal Failure Mechanisms**

- ➢ Address binding, hydraulic instability
- ➢ Address influencing factors
  - CBO Status (Isolated or not isolated)
  - RCP Status (running or tripped)

③ **Develop RCP Seal Failure Model**

- ➢ Use event tree structure
- ➢ Similar to model in BNL Report W6211-08/99

Revision of RCP Seal Failure Model - Main Tasks (Cont'd)-

④ **Quantify Model Parameters**

- ➢ Use combination of operating experience data, expert judgement and information from the RCP seal tests

⑤ **Develop Leak Rate Model Elements**

- ➢ End states on event tree are leak rates for the postulated combination of stage failures
- ➢ Use combination of operating experience data, expert judgement and information from the RCP seal tests and associated calculations

⑥ **Prepare Topical Report for Submittal to NRC**

- ➢ Revision to CE NPSD-0755

RCP Seal Failure Model Quantification

- **Operating Experience Data**
  - Use data from loss of cooling events to extent practicable
  - Use data from existing RCP seal tests to extent practicable
- **Expert Judgement**
  - Two round solicitation of expert judgement of likelihood of model parameters
  - Anticipated experts
    - Utility RCP systems engineers
    - Seal manufacturer representatives
    - ABB seal expert

RCP Seal Leak Rate Model

- **Range of Leak Rates to Address Postulated Combination of Stage Failures**
- **Use Operating Experience Data, Data from Existing Tests and Expert Judgement to Estimate the Various Leak Rates**
- **Will Not Conduct Any Additional Tests or Develop Detailed Thermal-Hydraulic Models of the Seals**

Revision of RCP Seal Failure Model
- Schedule-

Task	Date
1. Develop Draft Technical Descriptions of Seal Designs	12/3/99
2. Develop Draft Technical Descriptions of Failure Mechanisms	1/7/00
3. Develop RCP Seal Failure Model	1/28/00
4. Quantify Model Parameters	6/2/00
5. Develop Leak Rate Model Elements	6/2/00
6. Submit Topical Report	7/7/00

RCP SEAL DESIGN
Seal Cartridge Vendors

- **Byron Jackson (BJ) [Now FlowServe]**
  - **SU** — **1 plant (1 unit)**
  - **N-9000** — **5 plants (6 units)**
- **Sulzer Bingham**
  - **Four Stage** — **2 plants (4 units)**
  - **Three Stage** — **1 plant (3 units)**

RCP SEAL DESIGN-GENERAL FEATURES

- Hydrodynamic seals
- 4 stages, including vapor seal (3 stages at Palo Verde)
- Equal pressure reduction/stage - each stage capable of full system pressure for 4 stage seals, 43%, 43%, 14% for 3 stage seals
- Normal Controlled Bleed-Off (CBO) flow, 1-1.5 gpm for 4 stage seals, 3.2 gpm for 3 stage seals
- Seal injection not required (Palo Verde has injection)
- Stringent vendor QA programs
- Instrumented to monitor seal performance/leakage:
  - Individual stage pressure
  - CBO flow
  - CBO temperature
  - Alarms on CBO temperature

RCP SEAL DESIGN

Comparison Data

Design Feature	CEOG	Westinghouse
Number of Stages	4 (except Palo Verde)	3
Type of Seals	All hydrodynamic	First stage hydrostatic All others hydrodynamic
Pressure Breakdown	Equal press. /stage* (43%, 43%, 14% for Palo Verde)	Pressure reduction primarily by 1st stage
Seal Injection	Not Required (Palo Verde has injection)	Required
Design CBO Flow	1-1.5 gpm (3.2 gpm at Palo Verde)	3 gpm

*All stages capable of withstanding full system pressure – including vapor seal

RCP SEAL DESIGN TESTING

Summarized from 1994 presentation.

BJ, SU Design	**SONGS, 1978**	BJ-SU seal maintains integrity under loss of CCW conditions. (Test at BJ, pump operating).
BJ, SU Design	**St. Lucie, 1980**	BJ-SU seal maintains integrity under loss of CCW conditions.
KSB Design	**1983**	KSB seal maintain integrity under loss of CCW and loss of seal injection.
Bingham Design	**SCE, 1985**	Bingham seal maintain integrity following cooling. (Test at Alametos, Unit 3)
BJ & Bingham Designs	**AECL, 1986**	BJ-SU and Bingham seals maintain integrity under extreme temperature and pressure conditions
BJ N-9000 Design	**1988**	BJ- N-9000 seals maintain integrity under SBO conditions

SEAL FAILURE EVALUATION

Actual Experience

- **20 Events Involving Loss of CCW To 1 or more RCPs at a CE Plant**
  - **85% due to CCW Isolation**
  - **15% due to Partial LOOP**
- **5 Tests**
- **Total Number of pumps: 61**
- **Total number of stages: 232**
- **Number of stages failed: 4**
- **Number of seals failed: 0**

CLOSING REMARKS

Key Points

- *RCP Seals Used at ABB Plants Different Than Westinghouse and More Robust*
- *No Loss of Seal Cooling Event at an ABB Plant Has Ever Resulted in Uncontrolled Leakage*
- *ABB Is Revising Model For RCP Seal Failure Given Loss of Cooling to Address NRC Concerns*
- *Quantify Model Using Combination of Expert Judgement and Existing Operating Experience and Test Information*
- *Submit Topical in July, 2000*
- *Close Out RCP Seal Failure Issue for ABB Plants*